Student Perception of Learning Through Laboratory

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Abstract

Engineering courses, particularly undergraduate engineering courses, include practical learning through laboratory experiments. Laboratory experiments help students understand theoretical concepts. They also teach them practical skills and soft skills.

This paper presents the perception of students about laboratory experiments in various courses related to electrical and computer engineering technology. The student perceptions were obtained at the end of the semester via anonymous evaluations taken by the students for the laboratory courses (courses with both theory and laboratory components).These courses were taught by the lead author over a period of six years at two different institutions. This paper presents statistics based on the students' comments from anonymous evaluations for all the laboratory courses the lead author taught. Moreover, Indiana State University (ISU), where the lead author is currently teaching, allows instructors to include their own questions in anonymous evaluations. The lead author added two questions related to laboratories. The questions were student rated and appeared in the ISU questionnaires as: 1) Laboratory experiments help to understand theoretical concepts and 2) Laboratory experiments are interesting. This paper presents the ISU student ratings on these questions for various courses and also compares their ratings of questions with the overall student ratings for each specific course.

The findings of this paper shows how students perceive the laboratory experiments and whether they agree with the hypothesis: "Laboratory experiments help students understand theoretical concepts." The data were obtained from students of two different institutions and covered different courses taught over six years, which showed a consistency in student perceptions.

Keywords

Laboratory, student perceptions, experiments, practical skills.

Introduction

Engineering courses focus on practical learning through laboratory experiments. This is especially true for undergraduate courses. Laboratory experiments open the door to learning theoretical concepts through the practical skills required by their major. Soft skills of communication and teamwork are also taught through laboratory experiments which help students learn how to work in groups and write reports on experiments performed [1],[2]. Historically, the emphasis on laboratory in engineering education has varied [1] and relatively less literature is available on laboratory. A review of the *Journal of Engineering Education* literature shows that during the first five years of the journal's history (1993-1998) only 6.5 percent of the papers used laboratory as a keyword. This number reduced to an even lower

percentage of 5.2 in the next five years (1998-2002) [3]. Laboratory curricula are often designed with the goals of 1) relating theory to practice [4-8] and 2) increasing the motivation of students to pursue engineering education [9,10]. One method of assessing laboratory goals is through student satisfaction surveys [11,12]. Bye and Osen obtained student perceptions about three newly developed lab projects [11]. Whereas Edward [12] presents the perceptions of both students and instructors on the laboratory experience and its value in their course success in the School of Engineering at the Robert Gordon University, Aberdeen, Scotland. This paper is different than [12] as the data presented here is student perception about laboratory experiments for each individual course obtained at the end of semester through anonymous course evaluations.

This paper presents the opinions of students about laboratory courses in nearly a dozen different courses related to electrical and computer engineering technology. Student perceptions are obtained from end-of-the semester anonymous evaluations, which were taken by the students for the laboratory courses taught by lead author over the last six years at two different institutions. In the comments of anonymous evaluations, authors had observed that students often mention the laboratory experiments as the best part of courses, which have both theory and laboratory components. This paper compiles statistics about such comments from all the laboratory courses this author has taught. Most of these courses were taught more than once and data from all semesters is included. Moreover, Indiana State University (ISU), where the lead author is currently teaching, allows instructors to include their own questions for the anonymous evaluations. The lead author includes two questions related to laboratories in those custom questions. The lead author's questions are: 1) Laboratory experiments help to understand theoretical concepts, and 2) Laboratory experiments are interesting. Students reply to these questions on a five level Likert scale. This paper will present the student rating on these questions for various courses taught over two years and also compare those with the overall student ratings for each specific course. Some of the courses for which the student perceptions of laboratory values cover the following courses: DC Circuits and Design, AC Circuits and Design, Electronics, and Introduction to Robotics and Automation.

The findings of this paper will show how students perceive the laboratory experiments and whether they agree with the hypothesis that laboratory experiments help to understand theoretical concepts. This paper specifically shows the effectiveness of laboratory courses taught by the lead author and shows whether the proposed benefits of laboratory courses are delivered to students in their own perception. The data were obtained from students from two different institutions. The results of various courses taught over six years show consistencies in student perceptions.

The organization of this paper presents information about laboratory courses and the methods used which informed the student perception data about these courses, That data can be found in the Methodology and Results section. This section is categorized with respect to educational institutions because both institutions have different ways of collecting end of semester course evaluations by students. This paper ends with a conclusion of the presented data.

Methodology and Results

Since, the lead author has taught at two different educational institutions, the methodology of obtaining student perceptions of laboratory courses from end-of-semester anonymous evaluations are categorized with respect to each educational institution.

Educational Institution No 1 - Indiana State University (ISU)

The lead author has been faculty at ISU since fall 2019. She has taught several ISU laboratory courses every semester.

Data of student response from end-of-semester evaluations is presented from six courses over four semesters starting in fall 2019. These courses include both in-person and online courses as well as both undergraduate and graduate level courses. Most of the courses were taught over multiple semesters and to multiple sections in the same semester. Table No. 1 lists the courses and the necessary ID details, such as the section name, the course reference number and other important information

Table 1: Educational Institution No 1 Courses with Laboratory Component

Course Name	Online / In-Person	Undergraduate/ Graduate	Semester - Year	Section	Course Reference Number
DC Circuits	In-Person	Undergraduate	Fall-2019	1	C1-F19
			Spring-2020	1	C1-S20
			Fall-2020	1	C1-F20-1
				2	C1-F20-2
Introduction to Robotics and Automation	In-Person	Undergraduate	Fall-2019	1	C2-F19
			Fall-2020	1	C2-F20
			Spring-2021	1	C2-S21-1
				2	C2-S21-2
Discrete Transistor Theory and Circuit Design	In-Person	Undergraduate	Spring-2020	1	C3-S20
			Spring-2021	1	C3-S21
Discrete Transistor Theory and Circuit Design	Online	Undergraduate	Spring 2020	1	C4-S20
Process Control Technology	In-Person	Graduate	Spring 2020	1	C5-S20
AC Circuits	In-Person	Undergraduate	Spring 2021	1	C6-S21

All undergraduate courses had both theory and laboratory components. However, the graduate course was a project-based course. Enrollment varied across different courses and sections of each course, but the total number of students in these courses was less than 20. The number of experiments performed in each course was around 10.

The general end-of-semester evaluation questions included:

"What were the best things about this course?"

For each of the courses listed in Table No 1, the percentage of answers mentioning laboratory experiments as the best part of course is given in Table No 2. The overall average of these percentages is **71%**.

Table 2: Percentage of Answers Mentioning Laboratory as Best Part of the Course

Course Name	Course Reference Number	Percentage of General Comments Mentioning Laboratory as Best Part of Course
DC Circuits	C1-F19	52.94 %
	C1-S20	60 %
	C1-F20-1	57.14 %
	C1-F20-2	100 %
Introduction to Robotics and Automation	C2-F19	68.75 %
	C2-F20	90 %
	C2-S21-1	33.33 %
	C2-S21-2	66.67 %
Discrete Transistor Theory and Circuit Design	C3-S20	100 %
	C3-S21	83.3 %
Discrete Transistor Theory and Circuit Design (Online)	C4-S20	60 %
Process Control Technology	C5-S20	100 %
AC Circuits	C6-S21	54.54%

Moreover, this institution allows instructors to add custom questions for anonymous evaluations along with the generic questions.

This paper's lead author included two questions related to laboratories in the custom questions. The questions below are in the form of statements; thus, the students reply would be based on whether the statements are true or false based on the Likert scale:

1) **Laboratory experiments help to understand theoretical concepts**
2) **Laboratory experiments are interesting.**

Students replied to these questions on a five level Likert scale, where 1 means strongly disagree and 5 means strongly agree. Figure 1 reports the student rating on Question No. 1 and Question No. 2 for various courses taught over two years. It also compares those ratings with the overall student ratings for each specific course. Note these questions were not asked for the Spring 2020 laboratory courses due to COVID-19 when in-person labs were stopped on short notice during this semester.

The overall average student rating for Question No. 1 is **4.5** out of 5 and the overall average student rating for Question No. 2 is **4.6** out of 5.

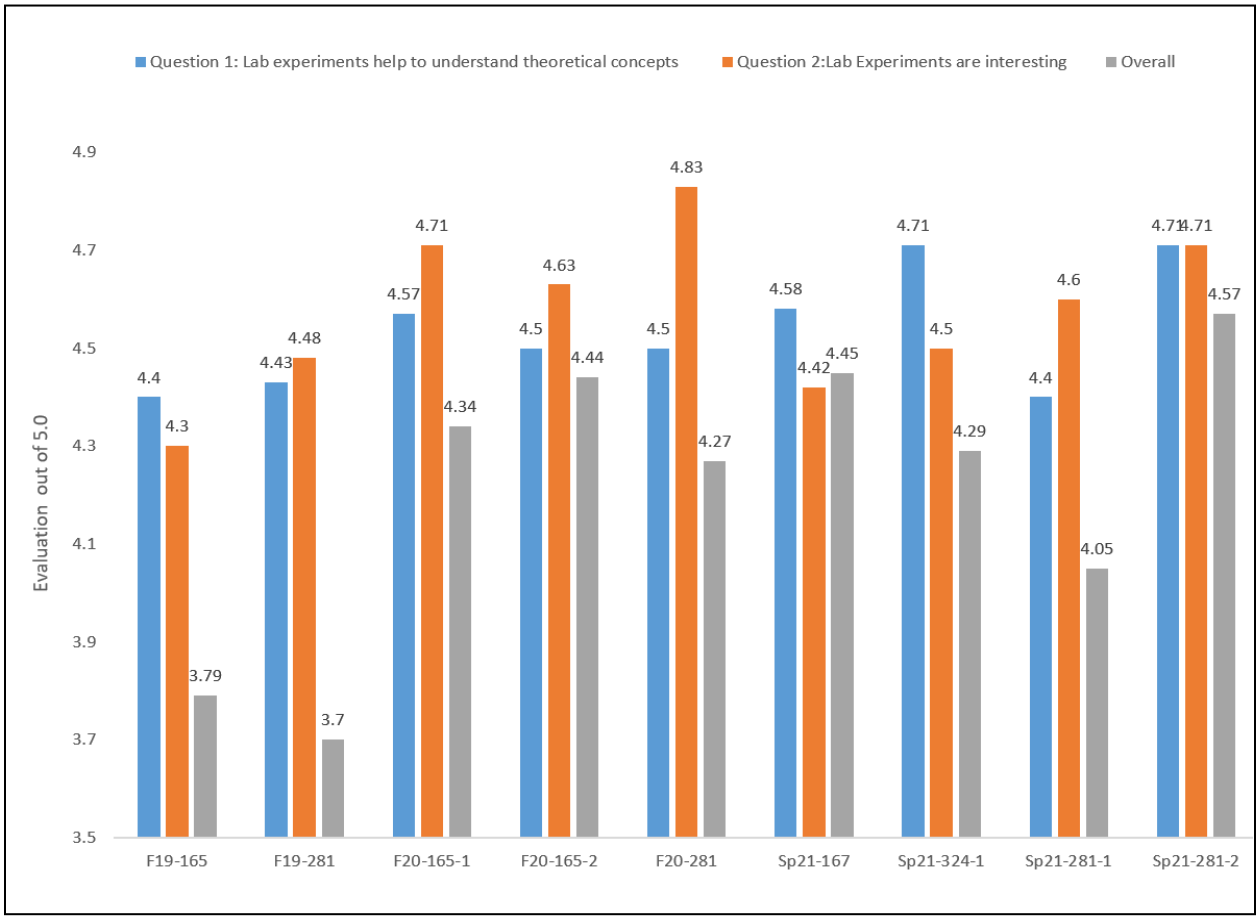

Figure 1. Overall Course and Laboratory Evaluations based on Question No. 1 and Question No. 2

Educational Institution No. 2 - Jacksonville University in Jacksonville, FL

The lead author was faculty at this institution from Fall 2015 to Spring 2019. She taught multiple courses which had both laboratory and theory components here. She also taught some courses which were only laboratory based and had no theory component, such as capstone project

courses. All the courses taught at this institution were taught in-person format at undergraduate level.

This institution had an anonymous end of semester evaluation system till spring 2016, which collected student comments on various questions including,

"What were the strengths of this course and the way it was taught?"

Authors have computed the percentage of replies to this question mentioning laboratory experiments for the courses which had both theory and laboratory components. Table No. 3 presents these percentages and information about courses.

The overall average of these percentages presented in Table No 3 is **65%**. Along with these courses there was one course (Introduction to Digital Circuits) for which the lead author had only taught the laboratory component of the course. All the students gave positive comments at the end of semester evaluation for that laboratory course. Note for Spring 2016, only one course's data is provided as other courses did not meet the required minimum number of evaluations and were not released.

Table 3: Percentage of answers mentioning labs as the strength of the course.

Course Name	Semester - Year	Percentage of answers mentioning labs as strength of course
Circuit Analysis	Fall-2015	36%
Engineering Orientation	Fall-2015	61%
Electronics	Spring-2016	100%

From Fall 2016 onwards, this institution used the IDEA evaluation system [13] which does not have such specific questions about the strengths of a course or best part of a course. Therefore, authors checked the general comments made by the students. The total number of positive general comments is determined for each course which had both a laboratory and theory component. If the general positive comments are more than one, then it was determined how many of those positive comments mentioned laboratory experiments explicitly. Finally, the percentage of general positive comments mentioning laboratory experiments was computed and reported in Table No 4.

Table 4: Percentage of general positive comments mentioning labs

Course Name	Semester - Year	Percentage of general positive comments mentioning labs
Engineering Orientation	Fall-2016	14%
Circuit Analysis	Fall-2017	50%
	Fall-2018	80%
Electronics	Spring -2018	50%
Introduction to Mechatronics	Spring -2018	50%

The overall average of these percentages presented in Table No 4 is **49%**.
The lead author has also taught laboratory-based or project-based courses such as a capstone project at this institution. The overall average student evaluation rating for such laboratory-based courses is 4.4 out of 5.

Conclusions

The results of anonymous evaluations by students at the end of semester for thirteen different laboratory courses taught by the lead author over a period of six years and at two different institutes. These results show how students perceive laboratory experiments. Students replied to question 1) Whether the laboratory experiments helped students understand theoretical concepts, and 2) Whether the laboratory experiments were interesting. The answers clearly showed student perceptions about the two hypothesized benefits of laboratory experiments. The very high scores averaged between 4.5/5 and 4.6/5. For the questions by students who took different courses, students agreed that the benefits of laboratory experiments were met in these various courses taught by the lead author. There was a consistency in student responses about laboratory experiments for various courses throughout the different semesters and for different educational institutions.

Students consistently mentioned laboratory courses as the best part of a course or the strength of a course as indicated by the average of 71% and 65% of the replies in Indiana State University and Jacksonville University, respectively.

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